

- II. "Researches on Solar Physics.—Second Series. On the Behaviour of Sun-spots with regard to Increase and Diminution." By WARREN DE LA RUE, Ph.D., F.R.S., President of the Royal Astronomical Society, BALFOUR STEWART, A.M., F.R.S., Superintendent of the Kew Observatory, and BENJAMIN LOEWY, Esq. Received January 10, 1865.

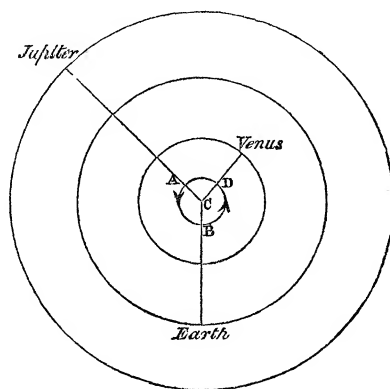
(Abstract.)

One of the authors of this paper having been led, from a preliminary investigation, to suspect that the behaviour of sun-spots with respect to increase and diminution refers to some extraneous influence, they resolved to investigate the behaviour in this respect of the spots observed by Carrington, in addition to the Kew photographs up to the present date.

The authors have thus examined materials embracing a period of ten years, and in this paper state the result.

The nature of their examination is thus described:—

If we imagine great circles of ecliptical longitude to be drawn from the sun's centre, every point of the sun's surface as it moves round by rotation will of course pass successively through each of those great circles, and every one of the planets will do the same as they move round by their own proper motions.



And if we imagine the plane of the paper to denote the plane of the ecliptic, and project upon this plane each body of our system, we shall have a scheme similar to the above, in which ADB, the inner circle, may represent the sun himself, the next circle, let us say the orbit of Venus, the next that of our earth, while the outer may denote the orbit of Jupiter. To an observer looking down upon our system from the north, all motions will be in the direction of the arrow-heads, that is to say, in a direction contrary to that of the hands of a watch, or left-handed, while ecliptical circles of

longitude will be represented by the various radii proceeding from the centre C, the angular difference between the two radii denoting the angular difference between the two corresponding longitudes. If the observer be stationed at the earth, all points of the solar surface will advance by rotation from left to right across the visible disk ; while the radii vectores of the inferior planets Mercury and Venus, which move faster than the earth, will appear to the terrestrial observer to have a left-handed rotation, in such a manner that the planet Venus will move from its place in the diagram to opposition, and ultimately come round to conjunction from the *left*. On the other hand, the superior planets, which move more slowly than the earth, will appear to the terrestrial observer to have a right-handed rotation, in such a manner that Jupiter will proceed from his place in the diagram to opposition, and ultimately come round in conjunction by the *right*. Also the point B, which occupies the central position of the visible solar disk, will have the same heliocentric longitude as the earth. Let us make the central longitude, or longitude corresponding to the position of the earth at the time of observation, our meridian, and let us reckon as negative all longitudes less than 180° to the left, and as positive all those less than 180° to the right. In this way a spot or point of the sun's disk, as it comes round by the left limb, will have the longitude -90 , while, as it disappears by the right limb, its longitude will be $+90$. Hence also the longitude of Jupiter in the diagram will be $-ACB$, while that of Venus will be $+BCD$. If the angle ACB is very large, we may say that Jupiter is much to the left, and if BCD is large, we may say that Venus is much to the right. In the examination to which the spots have been subjected, it has been endeavoured to ascertain, as nearly as possible, at what longitude any spot breaks out, or at what longitude it reaches its maximum and begins to wane. Very often, however, we are not able to assign the exact longitude of such an occurrence ; but yet, as will be seen in the sequel, we are able to determine, in a general way, the behaviour of spots.

The examination was made in the following manner. Mr. Carrington's original drawings were examined by two observers noting the behaviour of each spot, and the results again compared with Carrington's published maps, which give the behaviour of spots from day to day ; ultimately a list was obtained, no spot available for comparison being left out. A similar process was followed with regard to the Kew pictures.

It is to be remarked, that in making the examinations of the Carrington pictures, both observers were ignorant of the planetary configurations ; and that although with regard to the Kew pictures one observer knew the corresponding planetary configurations, yet his judgment, being checked by his fellow-observer, could not be biassed by any previous speculative views.

In a Table given, showing the behaviour of sun-spots from the beginning of 1854 to the end of 1864, it is seen that different spots occurring about the

same time on the sun's disk behave themselves in the same manner ; so that if one spot, after making its appearance, increases until the centre line, another will do the same ; or if one spot breaks out on the left or on the right, half the other spots about the same period have a tendency to break out on the same half. Examples of these are referred to in the Tables.

The authors suppose that this peculiarity of behaviour of spots can only be explained by reference to some influence from without. Suppose that such an influence, of a nature unfavourable to spot-production, exists, then, as spots are brought round to it by rotation, they will gradually wane ; and, on the other hand, as the surface departs from it, spots will break out. But while there is good evidence for believing in the existence of some such influence, it is a very difficult thing to determine its nature, and one which can only be done very imperfectly with our present knowledge.

The authors attempt to answer the following questions. Is this influence stationary ? or, if moveable, can it be traced to any of the planets of our system ?

The behaviour of each series of groups is then compared with the positions of the three planets, Mercury, Venus, and Jupiter, at the same date ; these planets being imagined to be the most influential ; since the first, though small, is very near the sun, the second is both near and tolerably large, while the last, although distant, is of very great mass.

In answer to the first question, Is the influence stationary ? it may be remarked that if it be so, the difference of behaviour noticed at different periods must be due to the position of the earth, or point of view at these periods with reference to the stationary influence, and hence in similar months of different years we should have a similar behaviour ; but it cannot be found from investigations that there is any connexion between a certain behaviour of sun-spots and a certain period of the year, and hence there is no reason to suppose that the external influence is fixed.

In the next place, does this influence, if moveable, move faster or slower than the earth ? If faster, it will proceed from conjunction to opposition, passing over the sun's disk from left to right. If we view it as one unfavourable to the production of spots, then, at first, when it is near conjunction, or a little to the left, the sun's surface to the right, receding from it, will break out into spots ; but as the influence moves on to the right, spots will come towards it from their first appearance, and will consequently decrease from the first. But if, on the other hand, the influence move more slowly than the earth, it will move from conjunction to opposition, from right to left ; so that a tendency of spots to form on the disk will be followed by a tendency to *increase*, not *decrease*, after making their appearance.

The order of the consecutive phenomena will thus be different in the two cases.

It is shown by a Table that a tendency of spots to break out is followed by a tendency of spots to decrease after making their appearance, and it is thereby concluded that the influence moves faster than the earth. This would seem to point to either Mercury or Venus as the agent in this matter, but the behaviour varies too slowly to be caused by the former. Venus, therefore, appears to be the influencing agent; and whether the behaviour of spots appears to depend on the position of this planet with reference to the earth, or point of view, the following Table, in which the spot-behaviour is compared with the corresponding position of Venus, will show:—

No. of series.	Behaviour.	Position of Venus.
1.	Increase to centre.	A good deal to left.
2.	Break out.	Conjunction.
3.	Decrease.	To right.
5.	Increase.	Near opposition.
6.	Break out.	Near conjunction.
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7.	Increase.	Opposition.
8.	Break out.	Near conjunction.
9.	Uncertain behaviour.	To right.
11.	Increase to centre.	Near opposition.
12.	Increase past centre.	Near opposition (to the left).
13.	Break out.	Near conjunction.
15.	Decrease.	To right.
17.	Increase to centre.	Near opposition.
18.	Increase past centre.	Near opposition (to the left).
20.	Break out.	Near conjunction.
22.	Stationary behaviour.	To right.
24.	Increase to centre.	Near opposition.
25.	Break out.	Near conjunction.
*26.	Uncertain behaviour.	To right.
27.	Increase to centre.	Near opposition.
28.	Increase past centre.	Near opposition (to the left).
29.	Break out.	Near conjunction.
31.	Decrease shortly after appearance.	To the right.
32.	Increase to centre.	Near opposition.

It will be seen from this Table that the behaviour of spots appears to be connected with the position of Venus in such a manner that spots dissolve when that part of the sun's surface in which they exist approaches the neighbourhood of this planet; while, on the other hand, as the sun's disk recedes from this planet, spots begin to break out and reach their maximum on the opposite side.

* Venus and Jupiter are here opposed to one another.

There are a few cases in which Venus and Jupiter are opposed to one another; the authors do not, however, suppose that these instances are sufficient to prove the fact of an action due to Jupiter, but think it right, in alluding to them, to state at the same time the opposed position of the two planets, since this may furnish a possible explanation of the uncertain behaviour of spots by which these series are characterized.

The results of this paper may be stated briefly as follows :—

Observed fact.—Spots appearing about the same time on the sun's disk behave in the same manner as they pass from left to right.

Legitimate deduction.—The behaviour of spots is influenced by something from without, and from the nature of the spot-behaviour the authors conclude that this influence travels faster than the earth; and finally, they find that the behaviour of spots appears to be determined by the position of Venus in such a manner that a spot wanes as it approaches this planet by rotation, and, on the other hand, breaks out and increases as it recedes from the neighbourhood of the planet, reaching its maximum on the opposite side.

In conclusion, it is not meant in this paper to convey the idea that Venus is the cause of the ten-yearly period of sun-spots, but merely that there is a *varying behaviour* of spots which appears to have reference to the position of this planet, or, putting aside the influencing agent, appears to have reference to certain ecliptical longitudes.

III. "On the Rapidity of the Passage of *Crystalloid* Substances into the Vascular and Non-Vascular Textures of the Body." By HENRY BENICE JONES, F.R.S. In a Letter to the Secretary. Received February 2, 1865.

DEAR DR. SHARPEY,—I am anxious that you should read to the Royal Society a short note containing the results of some observations I lately made on the rapidity of the passage of *crystalloid* substances into the vascular and non-vascular textures of the body.

It occurred to me that it might be possible to trace the passage of substances from the blood into the textures of the body by means of the spectrum-analysis, and with the assistance of Dr. Dupré some very remarkable results have been obtained.

Guinea-pigs have chiefly been used for the experiments. Usually no lithium can be found in any part of their bodies. When half a grain of chloride of lithium was given to a guinea-pig for three successive days, lithium appeared in every tissue of the body. Even in the non-vascular textures, as the cartilages, the cornea, the crystalline lens, lithium would be found.

Two animals of the same size and age were taken; one was given 3 grains of chloride of lithium, and it was killed in eight hours; another had no